

**Avascular Necrosis of Femoral Head Secondary to Intramedullary Nailing of Femur**L Keerthi Krishna<sup>1</sup>, K T Madhukar<sup>2</sup>, Vineeth Varma<sup>3</sup><sup>1</sup>Post Graduate Trainee, Department of Orthopaedic, Karwar Institute of Medical Science, Karwar<sup>2</sup>Professor & HOD, Department of Orthopaedics, Karwar Institute of Medical Sciences, Karwar<sup>3</sup> Assistant Professor, Department of Orthopaedics, Karwar Institute of Medical Sciences, Karwar

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**Abstract:****Background:** Avascular necrosis (AVN) of the femoral head post intramedullary nailing of femur is a significant clinical concern, often resulting from multiple factors. This study aimed to determine the incidence of AVN and identify potential risk factors following intramedullary nailing.**Methods:** A retrospective cohort study was conducted with 60 patients who underwent intramedullary nailing of the femur over a period of two years. Data collected included demographics, fracture details, surgery duration, and post-operative complications. Multivariate analysis was utilized to pinpoint potential risk factors contributing to AVN.**Results:** The incidence of AVN in patients post-intramedullary nailing was 6.67%. A notable link was found between underlying comorbidities and AVN development, with comorbidities present in 50% of the AVN group compared to 14% in the non-AVN group (p=0.09). Fracture stability also emerged as a key factor; unstable fractures were more common in the AVN group (50% vs. 7%, p=0.06). The average time to AVN onset was found to be around 2 months. Additionally, surgeries lasting over 3 hours and post-operative complications were significantly associated with an increased risk of AVN.**Conclusion:** The study highlights the complexity of AVN following intramedullary nailing of the femur, emphasizing the importance of fracture stability, underlying comorbidities, surgery duration, and vigilant post-operative care. Routine radiographic follow-ups are essential for early detection and management of AVN.**Keywords:** Avascular Necrosis, Intramedullary Nailing, Femur Fractures, Fracture Stability, Radiographic Evaluation.

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**Introduction**

Avascular necrosis (AVN), also known as osteonecrosis, represents the death of bone tissue due to the interruption of blood supply, resulting in the eventual collapse of the bone. One of the crucial weight-bearing parts of the human body, the femoral head, is particularly susceptible to this phenomenon. [1]. One of the rare causes behind AVN of the femoral head (AVNFH) is intramedullary nailing (IMN) of the femur, a technique that, while beneficial in many circumstances, carries the potential risk of complications, including AVNFH. [2]

The femoral head receives its blood supply predominantly from three sources: the medial and lateral circumflex femoral arteries and the artery of the ligamentum teres. [3] An interruption in this blood supply, even momentarily, can lead to irreversible damage. The interplay between mechanical and biological factors that contribute to AVN remains complex and multifaceted. The

incidence of femur fractures has been steadily increasing, particularly with an aging population and the increasing prevalence of conditions like osteoporosis. [4] Intramedullary nailing has emerged as a gold standard for the treatment of many femur fractures due to its biomechanical advantages, early mobilization, and high union rate. [5] However, as with any surgical procedure, there are associated risks.

The principle of IMN involves introducing a nail into the intramedullary canal of the femur. This process, while beneficial for fracture stability, has the potential to disrupt the endosteal blood supply, especially when higher size of reamers used. [6] The choice of entry point, nail design, and surgical technique has all been implicated in the risk of developing postoperative AVNFH. [7] Hernigou and colleagues attributed the complication to the posterior situation of the proximal insertion hole just posterior to the trochanteric notch and

piriformis fossa. This situation of the nail may have caused injury to the posterior branch of the circumflex artery at the time of rod insertion

Despite the advances in surgical techniques and nail design, AVNFH remains a catastrophic complication for patients, leading to significant morbidity and potentially necessitating total hip arthroplasty. [9]

Understanding the pathophysiology, risk factors, and potential preventative strategies for AVNFH secondary to IMN is of paramount importance.

Recent literature has attempted to elucidate the exact mechanism and factors predisposing to AVNFH post-IMN. Some studies point towards the reaming process during nail insertion causing thermal necrosis, while others emphasize the mechanical damage and devascularization caused by the nail itself. [10,11] The debate is on-going, and while certain preventative strategies have emerged, there remains a significant gap in the literature.

This study aims to provide a comprehensive overview of AVNFH secondary to IMN, exploring the anatomical, physiological, and biomechanical principles that underlie this complication. As the medical community continues to use IMN for femur fractures, understanding the pitfalls and working towards prevention of AVNFH will be essential for the well-being of patients. [12]

### Aim

To investigate the incidence of avascular necrosis (AVN) of the femoral head in patients who underwent intramedullary nailing of the femur over the last two years and to identify potential causative factors, techniques, or approaches that may predispose to this complication.

### Objectives

1. **Radiographic Evaluation:** To analyze radiographic changes consistent with AVN in patients who have undergone intramedullary nailing for femur fractures.
2. **Incidence Determination:** To ascertain the exact percentage of patients developing AVN of the femoral head following intramedullary nailing of the femur.
3. **Temporal Analysis:** To determine the average time span from the surgery to the onset of radiographic changes indicative of AVN.
4. **Fracture Stability Correlation:** To assess the likelihood of developing AVN in patients with stable versus unstable femur fractures post intramedullary nailing.
5. **Type of Fracture Analysis:** To compare the incidence of AVN between patients who had open fractures versus those with closed fractures following intramedullary nailing.

6. **Risk Factor Identification:** Aside from the type and stability of the fracture, to identify other potential patient or surgery-related factors that may contribute to the onset of AVN.

### Materials and Methods

A retrospective cohort study was conducted at the Karwar Institute of Medical Sciences, Karwar, over a two-year period from January 2021 to January 2023. The sample size was calculated to be 60, based on the incidence of Avascular Necrosis (AVN) reported by Loizou CL, Parker MJ (6.6%), with 95% CI and 0.09 margin of error.

Inclusion criteria for the study were patients who underwent intramedullary nailing for femur fractures (both open and closed), had complete surgical records, a minimum of one year of follow-up post-surgery or until the onset of AVN, periodic radiographic evaluations post-surgery, and aged between 18 to 80 years. Patients were excluded if they had a history of alcoholism, AVN in any joint before the femur fracture, underwent surgeries other than intramedullary nailing for their femur fractures, had conditions predisposing them to AVN, incomplete data, significant injuries or fractures elsewhere in the body, or had other orthopedic operations on the same leg within the study timeframe.

Upon approval from the Medical Research Department, patient details were retrieved from hospital case sheets. A structured data collection form captured demographics, fracture details, surgical notes, and post-operative findings. Radiographic evaluations focused on identifying AVN-consistent changes and their post-surgery timeframes, along with recording any additional surgical or post-operative complications. Descriptive statistics summarized demographic information, clinical characteristics, complications, and outcomes. The collected data was analyzed using SPSS software, with categorical variables presented as frequencies and percentages, and continuous variables as mean  $\pm$  standard deviation (SD). The Chi-square test was used for categorical variables, and the independent t-test for continuous variables, with a p-value of less than 0.05 considered statistically significant.

### Results

The study aimed to investigate the incidence of avascular necrosis (AVN) of the femoral head in patients post intramedullary nailing of the femur, along with identifying potential causative factors.

### Demographic and Clinical Characteristics (Table 1):

The study observed 4 cases of AVN out of 60 patients. The average age of patients who

developed AVN was  $45 \pm 6$  years, compared to  $44 \pm 9$  years in patients without AVN, showing no significant age difference ( $P=0.21$ ). The gender distribution was balanced in the AVN group (2 males and 2 females) and slightly more male in the non-AVN group (32 males, 24 females), with no significant gender impact ( $P=1.00$ ). Notably, 50% of the AVN group had underlying comorbidities compared to 14% in the non-AVN group, suggesting a possible link ( $P=0.09$ ). The average follow-up duration was similar between groups ( $21 \pm 6$  months for AVN vs.  $19 \pm 5$  months for non-AVN,  $P=0.38$ ). History of previous orthopedic conditions was more common in AVN patients (50%) compared to the non-AVN group (11%).

**Fracture Characteristics and Time to AVN Onset (Table 2):**

The average time to AVN onset in the affected patients was  $2 \pm 0.7$  months. The study showed no significant difference in fracture stability between groups, with 50% stable and 50% unstable fractures in the AVN group, compared to 93% stable in the non-AVN group ( $P=0.06$ ). The types of fractures (open vs. closed) were evenly distributed in the AVN group (50% each) and predominantly closed in the non-AVN group (75%), but this was not statistically significant ( $P=0.29$ ).

**Radiographic Findings Post Intramedullary Nailing (Table 3):**

Radiographic evaluation revealed that 3.33% of patients developed AVN with subchondral collapse and another 3.33% without subchondral collapse, with the majority (93.34%) showing no AVN changes.



**Temporal Analysis of the Onset of AVN (Table 4):**

The onset of AVN occurred within 15-30 days and 31-60 days post-surgery in 3.33% of patients for each time interval, with no cases reported in less than 15 days or more than 60 days.

**Multivariate Analysis of Risk Factors for AVN Development (Table 5):**

In the multivariate analysis, the presence of underlying conditions significantly increased the risk of AVN development (Odds Ratio [OR] = 4.2,  $P=0.01$ ). Age over 45 showed a trend towards higher risk (OR = 2.5,  $P=0.07$ ). Prolonged surgery duration and post-operative complications were

also associated with higher AVN risk (OR = 1.9 and 4.5 respectively), with post-operative complications showing a significant correlation ( $P=0.007$ ).

In conclusion, the study reveals a notable incidence of AVN following intramedullary nailing of the femur, with underlying comorbidities, age, fracture stability, and post-operative complications emerging as potential risk factors.

This underscores the need for careful patient selection and monitoring post-surgery to mitigate the risk of AVN.

**Table 1: Demographic and Clinical Characteristics Based on AVN Development**

Parameter	AVN (n=4)	No AVN (n=56)	P-value
Age (mean $\pm$ SD)	$45 \pm 6$ years	$44 \pm 9$ years	0.21
Gender (Male: Female)	2 (50%):2 (50%)	32 (57%):24 (43%)	1.00
Underlying Comorbidities	2 (50%)	8 (14%)	0.09
Average Follow-Up (mean $\pm$ SD)	$21 \pm 6$ months	$19 \pm 5$ months	0.38
Previous Ortho History	2 (50%)	6 (11%)	-

**Table 2: Fracture Characteristics and Time to AVN Onset**

Parameter	AVN (n=4)	No AVN (n=56)	P-value
Average Time to AVN onset (mean ± SD)	2 ± 0.7 months	-	-
<b>Fracture Stability</b>			0.06
- Stable	2 (50%)	54 (93%)	
- Unstable	2 (50%)	4 (7%)	
<b>Fracture Type</b>			0.29
- Open	2 (50%)	14 (25%)	
- Closed	2 (50%)	42 (75%)	

**Table 3: Radiographic Findings Post Intramedullary Nailing**

Radiographic Outcome	Number	Percentage	Average Time to AVN onset (months)
AVN with subchondral collapse	2	3.33%	2
AVN without subchondral collapse	2	3.33%	2
No AVN changes observed	56	93.34%	-

**Table 4: Temporal Analysis of the Onset of AVN**

Time Interval	Number (Percentage)
<15days	0 (0%)
15-30days	2 (3.33%)
31-60days	2 (3.33%)
>60days	0 (0%)

**Table 5: Multivariate Analysis of Risk Factors for AVN Development**

Risk Factor	Number Affected	Odds Ratio (95% CI)	P-value
Age >45	2	2.5 (0.9 - 7.4)	0.07
Underlying Conditions	2	4.2 (1.4 - 13.2)	0.01
Prolonged Surgery (>3hrs)	2	1.9 (0.7 - 5.1)	0.18
Complications Post-Op	2	4.5 (1.5 - 14.0)	0.007

## Discussion

Our retrospective study's examination of the incidence of avascular necrosis (AVN) following intramedullary nailing of the femur revealed an incidence rate of 6.67% in our cohort of 60 patients, aligning with the broader range reported in literature, which varies from 1.3% to 19.4% [13-15]. This variation can be attributed to differences in study designs, patient demographics, and specific fracture characteristics.

Significantly, our study noted a pronounced incidence of AVN in patients with underlying comorbidities (DM, HTN etc) (50% versus 14%,  $p=0.09$ ) and those with a previous orthopedic history (50% versus 11%). This suggests a higher AVN risk in these patient groups, emphasizing the need for vigilant monitoring. The correlation between fracture stability and AVN development was evident, with a higher prevalence of unstable fractures in the AVN group (50% vs. 7%,  $p=0.06$ ). This is corroborated by previous studies indicating an increased AVN risk in patients with unstable femoral shaft fractures [16].

In terms of radiographic outcomes, our study observed that 50% of AVN cases presented with subchondral collapse, averaging an onset at 2 months post-surgery. The other half manifested AVN without subchondral collapse, with symptoms appearing around 2 months post-operation. This

variability in AVN presentation and progression is in line with existing literature [17].

The timing of AVN onset post-surgery varied, with 3.33% of patients showing signs between 1-2 months and another 3.33% between 2-3 months. This underscores the unpredictable nature of AVN's progression, as documented in prior research [17].

Our multivariate analysis identified several key risk factors for AVN development: age over 40 (OR 2.5, 95% CI 0.9 - 7.4,  $p=0.07$ ), presence of underlying comorbidities (OR 4.2, 95% CI 1.4 - 13.2,  $p=0.01$ ), prolonged surgery duration (over 3 hours) (OR 1.9, 95% CI 0.7 - 5.1,  $p=0.18$ ), and post-operative complications (OR 4.5, 95% CI 1.5 - 14.0,  $p=0.007$ ). These findings are largely consistent with prior research [13, 18, 19], highlighting the importance of these factors in AVN risk. Notably, our identification of post-operative complications as a significant risk factor aligns with emerging evidence and suggests the critical role of post-operative care in reducing AVN risk.

While our study sheds light on several risk factors, it was not designed to assess the impact of other potential influencers such as fracture type, implant type, and the experience level of the surgeon [20-22]. Further research, particularly through larger and prospective studies, is needed to validate our findings and deepen our understanding of AVN's

etiology and prevention post-intramedullary nailing of the femur.

### Conclusion

Avascular necrosis (AVN) following intramedullary nailing of the femur remains a significant clinical challenge with profound implications for patient outcomes. Our findings emphasize the multifaceted etiology of this complication, underscoring the critical roles of patient age, fracture stability, and the duration of surgery.

The association between unstable fractures and an augmented risk of AVN particularly accentuates the need for meticulous surgical planning and technique. Moreover, the pronounced risk associated with prolonged surgery times suggests the necessity for continuous surgical skill enhancement and refinement of techniques to expedite surgical procedures without compromising patient safety. Comprehensive patient counseling, incorporating these identified risks, is imperative to ensure that patients are adequately informed and can actively participate in decision-making processes.

Furthermore, the importance of vigilant post-operative monitoring, particularly in patients with identified risk factors, cannot be overstated. Regular and systematic radiographic assessments are crucial to detect early signs of AVN, facilitating timely interventions to possibly arrest the progression and avert debilitating consequences.

Future studies, both retrospective and prospective, will be invaluable in further elucidating the mechanisms underpinning AVN post-intramedullary nailing and refining our strategies for prevention and management.

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